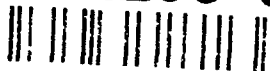


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TECHNICAL REPORT  
NATICK/TR-91/030

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# TRAYCANS: TINPLATE VS TIN-FREE STEEL -- PHASE I

By  
Jeanne M. Ross

May 1991

Final Report  
June 1989 - July 1990

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## **PREFACE**

This study was initiated by the Subsistence Protection Branch (SPB), Food Technology Division (FTD), Food Engineering Directorate (FED), U.S. Army Natick Research, Development and Engineering Center (Natick) in cooperation with Central States Can Company (CSC) of Massillon, Ohio.

The primary goal was to find a suitable replacement for the current tin-free steel traycan, which was exhibiting corrosion problems that resulted in a traycan that did not provide the required three year shelf life. The decision to conduct this study was made jointly by the Project Office, Army Field Feeding System (PO AFFS), Office of The Deputy Chief of Staff for Logistics (ODCSLOG), Defense Personnel Support Center (DPSC) and Natick.

This report is Phase I of a two-phase study. Phase II of the study will be completed in December 1992.

## **ACKNOWLEDGEMENTS**

The author is indebted to Messrs. Peter Burke (retired), Jack Barber, James Herne, and Jay Jones, all of the Subsistence Protection Branch, and Ms. Susan Gagne, Project Officer, Tray Pack Program, for their assistance in the planning and completion of Phase I of this study. Also, acknowledgment is made to the staff at CSC, particularly Mr. Frank LePera, for their technical support.

## SUMMARY

In May-June 1987, Tray Pack corrosion problems surfaced in several geographic locations. Subsequent investigations concluded that the shelf life of the traycan may be extended by converting the current traycan from tin-free steel to tinplated steel. To accomplish this, an optimal traycan had to be developed composed of the best available steel substrate combined with the best available -- and most compatible -- double enamel system.

An extensive three year storage study was designed which included all essential variables, such as storage temperature, product, and can variable. The storage study was designed to consist of two phases and to represent 36 months of real time storage. Phase I was an intensive study and was completed within six months. Phase II will involve an extension of the study to include an additional 30 months until its completion in December 1992. This report discusses the findings of Phase I.

Five can variables were filled with six different products -- beef stew, carrots, corn, lasagna, chili con carne, and omelet w/ham -- which were representative of the range of products currently in the menu cycle. The filled and processed traycans were stored at 40, 80 and 100°F to simulate the wide temperature variation commonly found in the military distribution and storage system.

Phase I of the study was designed to be completed in six months, using frequent withdrawals in order to determine the best performing candidate, by virtue of visual and microscopic examination. Samples were withdrawn from 40°F storage every 8 weeks, from 80°F every 4 weeks, and from 100°F every 2 weeks. Samples were inspected for the following aberrations - gray spots, blisters, pitted corrosion, oven dust, coating seeds, delamination, scratches and mechanical abrasion.

Test results showed that tinplate did, in fact, provide improved resistance to corrosion over the current tin-free steel traycan during 6 month storage at 40, 80 and 100°F. Natick recommended that the traycan composition be converted to #75/#35 (0.375/0.175 pounds/base box) differentially coated tinplate with an aluminum vinyl/epoxy phenolic double coating system, and that a sheet feed system be used in lieu of the current coil feed system. This recommendation was made to support a request, already stated in preface, to develop a suitable replacement for the current tin-free steel traycan. The recommendation to convert to the above referenced traycan was accepted by ODCSLOG on 16 May 1990. Subsequently, in December 1990, Natick recommended that the tinplate weights be reduced from #75/#35 to #75/#25, resulting in an increase in material availability and a decrease in cost without any adverse affect on shelf life.

## TRAYCANS: TINPLATE VS. TIN-FREE STEEL — PHASE I

### INTRODUCTION

#### Background

During the 1970's, the military services were considering new or redesigned field feeding systems in order to reduce the number of trained cooks in the field. U.S. Army Natick Research, Development and Engineering Center (Natick) began investigating the possibility of developing hermetically sealed, multi-serving containers of preprepared foods that would be compatible with the Army Field Feeding System. Initially the container had been made experimentally of aluminum, steel (tinplate and tinfree), and injection molded polymeric materials. However, by the mid-1970's, Kraft, Inc., and Central States Can Co. (CSC), independently of each other, developed rectangular tinplate and tin-free steel (TFS) containers, respectively, with double-seamed lids.

The rectangular configuration of the current traycan - as the container is called - is the result of the original intent to have a half-size steamtable container that would fit into standard steamtable openings. The final design consisted of a two-piece container (tray and lid) composed of TFS, which had the same capacity as a No. 10 can, but required a considerably shorter processing time in a still retort to achieve commercial sterility. Heat penetration studies showed that the flat, rectangular shape, as compared to the cylindrical shape, reduces the processing time by 50%. The Tray Pack, as the filled traycan is called, is a multipurpose rectangular container which conveniently serves as a package, shipping vessel, heating pan, and a serving tray. Product development and field acceptance testing were conducted, making Tray Packs available for procurement in 1983. CSC has been, and continues to be, the only supplier for the traycan.

In 1984, the basis weight of the steel was increased from 75 to 90 pounds per base box (base box or BB = 112 sheets of 14" x 20" steel plate) and, in 1985, the coating system was changed from a single vinyl to a vinyl/epoxy two-coat system to provide increased corrosion resistance. In 1988, the body of the traycan was redesigned to incorporate reinforcement ribs or beads into the bottom of the traycan. These reinforcements increased durability and strength during transit and storage.

To maximize the efficiency of the Class I distribution system, while reducing dedicated Class I manpower, Natick developed an optimal meal module, entitled Meal Module, Tray Pack, 36 Soldier. The meal module contains enough Tray Pack food, disposables, and eatingware to provide a complete meal for 36 soldiers. Assembly sites of the meal module are located on both the East and West coast to facilitate world wide distribution. The meal modules are assembled at Defense Depot Mechanicsburg (DDMP), Mechanicsburg, PA and Defense Depot Tracy (DDTC), Tracy, CA.

In May of 1987, reports of rusted and leaking traycans were received from Ft. Clayton, Panama. On-site investigation confirmed these reports, but further identified that the problem occurred only in two lots from 1983 and 1984 Date of Pack (DOP). In June 1987, Defense Personnel Support Center (DPSC) reported defective traycans that were discovered in seven other geographic locations. Subsequent examination of samples verified the existence of leakers and were similar to the defects found in Panama. The defects showed up in the form of "gray spots". These were small, gray-colored spots found on the exterior of the traycan. Some traycans became leakers if the gray spot was gently probed with a sharp object.

In July 1987, the Tray Pack Task Force was formed to determine the origin of gray spots and pinholes, and identify short and long-term solutions. The Task Force consisted of representatives from the Office of the Deputy Chief of Staff for Logistics (ODCSLOG), Defense Logistics Agency (DLA), Defense Personnel Support Center (DPSC), Natick, Office of The Surgeon General (OTSG), United States Department of Agriculture (USDA), industry (CSC), and a private consultant with extensive can and food technology experience.<sup>1</sup> The Task Force recommended that Natick investigate the feasibility of converting the traycan from TFS to tinplated steel. However, CSC suggested that the feasibility of a new coating system be investigated before a full commitment can be made to convert to the tinplated traycan. The vinyl coating used at the time was soft and susceptible to scratching and abrasion.

In early 1989, a new coating system was incorporated into the TFS traycan. This coating system was manufactured by Dexter Midland and initial storage studies found it to be an improvement over the existing Valspar coating system. However, Dexter Midland coated traycans began exhibiting problems soon after full scale production and further manufacturing of these traycans was terminated. At this time, the decision was made -- by agencies represented on the Task Force -- to develop a tinplated steel traycan with a new coating system. This report discusses the development of the experimental variables, their subsequent evaluation, and the results of that evaluation.

The current traycan (as of the printing of this report) is composed of electrolytic chromium coated steel (ECCS) with a coating of epoxy and vinyl on the interior and an epoxy coating on the exterior (See Figure 1).

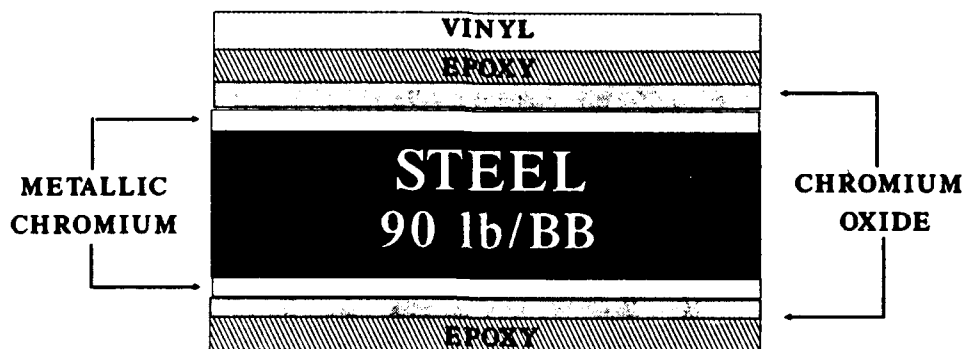


Figure 1. Composition of Tin-Free Steel

ECCS has a chrome-chrome oxide surface treatment which serves as a rust preventative until it can be coated. The chemical treatment also serves as a protective coating underneath the enamel coating. Typical amounts of the chemical treatments are: 5 mg/ft<sup>2</sup> of surface, covered by chromium oxide film containing 0.7 to 2.5 mg/ft<sup>2</sup> of metallic chromium. The traycan measures 1001 x 1206 x 200 (10-1/16 in x 12-6/16 in x 2 in ) as shown in Figure 2 and has the capacity of approximately 105 ounces, the same as that of a 603 x 800 can (6-3/16 in x 8 in ) - or what is commonly referred to as a #10 can. The basis weight of the steel is 90 pounds per base box (lb/BB). As shown in Figure 2, the body design is reinforced with six longitudinal beads or ribs approximately 0.050 ± 0.010 in. deep. The beads are 9 in by 3/4 in in length and width. The lid is reinforced with corner beads and there is an expansion area with a smooth panel, 8-7/8 in in length and 6-5/8 in in width, which accommodates the can labeling.

Many attempts have been made by the can industry to find a universal, all-purpose can (i.e. one metal substrate/coating system for all products and conditions). Can integrity is a function of many factors. Among the factors which must be considered are: (1) chemical composition and physical properties of the steel (strength, composition, final shape), (2) type and application of the enamel coating (continuity and thickness), (3) container construction, (4) relative corrosivity of the product which is to be canned, (5) thickness of the tin coating (when tinplate is used), and (6) seaming process to include the elimination of oxygen. When faced with these variables and the fact that traycans are manufactured using a one-step process, via a 110 ton press, it becomes clear that many problems are encountered when developing one can for all products and conditions. However, due to the logistics of the military system, as well as maintaining an efficient production base for the can, a universal traycan is essential.

As previously stated, the Tray Pack Task Force concluded that tinplated steel would provide additional corrosion resistance. The corrosion resistance of tinplated cans are a function of the thickness, and uniformity and manner in which the organic and tin coatings are applied. The tin coating thickness used can vary, depending on factors such as the product to be packed, shelf life requirements, and storage conditions. Tin, in contact with the product, sacrificially corrodes to protect any minute areas of base steel and iron-tin alloy exposed due to a void in the internal coating system. Within the can, the amount of tin gradually decreases while the areas of exposed steel and alloy increases. This leads to a point where, eventually, the steel may be attacked rapidly. In a can that is differentially coated, a coating such as #35 (0.175 lb/BB) may be applied on the exterior side of the plate and a heavier coating such as #75 (0.375 lb/BB) to the interior side. Thus, more protection is provided on the interior of the cans which is in contact with the product, while a lighter tin coating, adequate for exposure under most normal distribution conditions, is applied to prevent exterior corrosion of the traycan.

Organic coatings are used in canned foods to prevent chemical interaction between the product and the container. Preventing these chemical interactions helps to preserve the quality of the food and improve the integrity of the container, thereby increasing the shelf-life of both the food product and the can.

The coatings are normally applied by one of two methods: (1) applied to the individual flat sheets and slowly cured at temperatures below the melting point of tin (450°F); or (2) applied to continuous tinplate stock supplied in

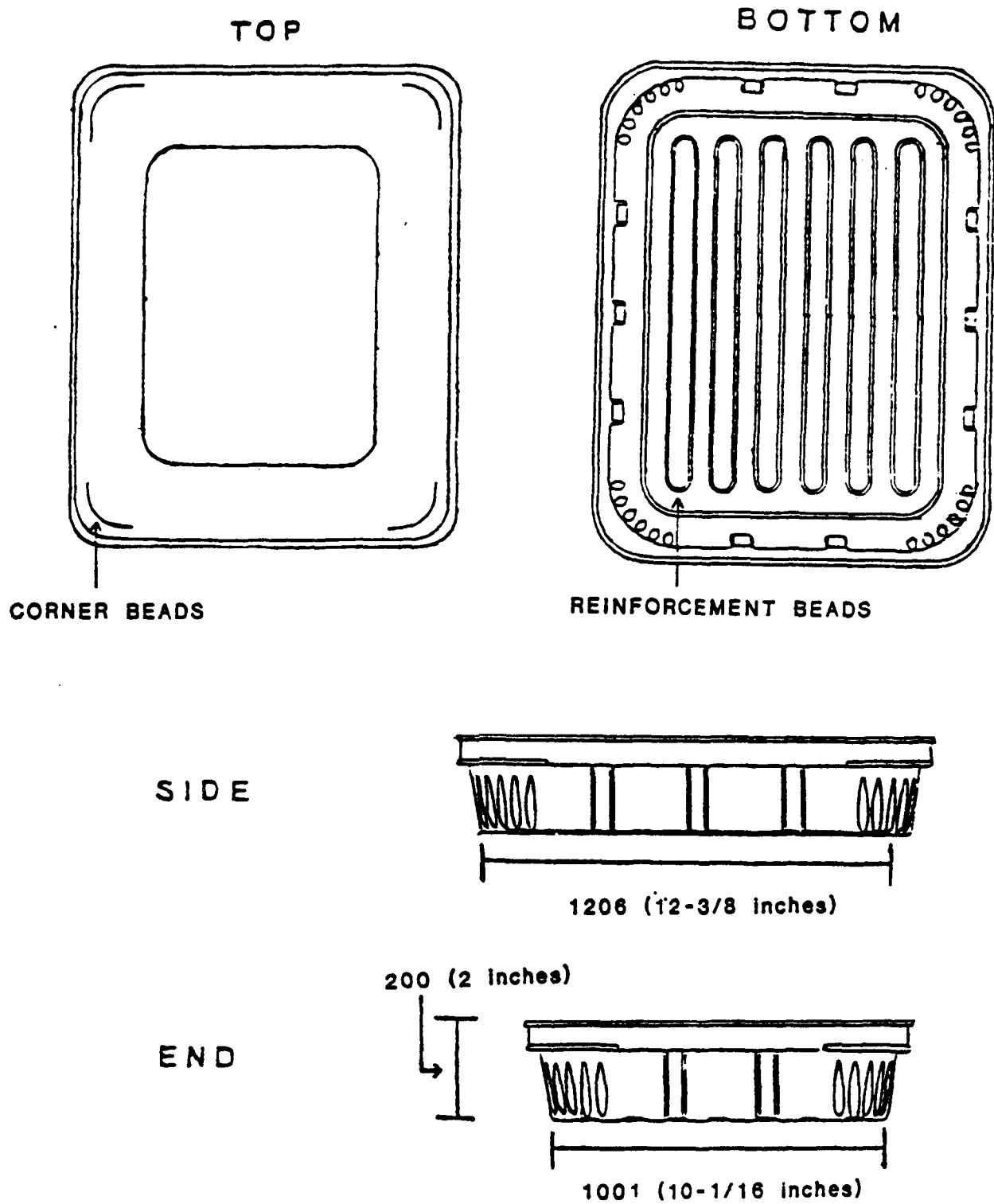


Figure 2. Traycan Configuration

coils and then cured for very short periods of time at high temperatures (maintaining a peak metal temperature below the melting point of tin).

Although many attempts have been made to develop an all-purpose can enamel, they have not been successful to date. Some 20 different enamels are currently used to meet the requirements of the many products now packed in cans. Oleoresins are used to protect the natural pigment of dark colored fruits, such as cherries and beets. Epoxy resins are often used for meat and dairy products. Release agents are sometimes incorporated to prevent the product from sticking to the container. Vinyl resins are usually used as a double coating system in conjunction with an oleoresinous or a phenolic enamel and are commonly applied to can interiors which will contain more corrosive products. Organic coatings are not used for light fruits such as peaches, apples and pears. The reducing action of the tin, reacting with the fruit and syrup within the can, retards darkening and maintains the color of these products, which in this case is considered beneficial.

A can lining must be nontoxic; not affect the flavor or color of the food; be easily applied to the steel substrate; have excellent adhesion properties (i.e., not delaminate or blister during can sterilization and storage); be resistant to the normal abuses encountered during can manufacturing and be economical.

In June 1989, Natick and CSC initiated development of a "universal can" to be fabricated from tinplated steel. This was accomplished by conducting an extensive storage study to find the traycan with the best available metal substrate combined with the best available (and most compatible) double enamel system, resulting in a cost effective traycan with an improved shelf life. Tinplate was chosen due to the protective qualities of tin. Although it was believed that the addition of tin would extend the shelf life of the traycan, it must be understood that product aggressiveness is a major factor affecting the shelf life of the container. Regardless of traycan composition, some products will have a shorter shelf life than others by attacking the interior of the traycan more aggressively.

#### EXPERIMENTAL APPROACH

In July-August 1989, CSC initiated a study to evaluate various steel substrates and coating formulations. The study involved the determination of an optimum steel substrate in terms of economics, availability and corrosion resistance. Further, various coating systems were evaluated via coating trials and screening tests to select optimum coating variables in terms of such factors as adhesion, water resistance, impact resistance, salt resistance and uniformity. In July 1989, CSC conducted coating trials of various formulations in order to initiate screening and in-house testing. Various coating formulations from three coating suppliers (Dexter Midland Division of The Dexter Corp., Waukegan, IL; Reliance Universal, Columbus, OH; and The Valspar Corp., Pittsburgh, PA) were applied to two 90# electrolytic tinplate (ETP) substrate variables. The ETP substrate variables were #75/#35 Matte and #75/#25 K Plate (K Plate refers to ETP which has been reflowed for better uniformity). The coatings were applied using both the sheet and the coil coating methods to pursue various methods of coating application. The sheet coating was conducted at CSC. Since CSC does not have facilities for coil coating, the coil coat was applied at Enamel Products and Plating (EP&P),

McKeesport, PA. The coating trials resulted in 32 steel substrate/coating system variables to evaluate.

In August-September 1989, a battery of 15 tests - 8 of which are approved by the American Society for Testing and Materials (ASTM) - were conducted on the resulting 32 coating system/steel substrate variables. These tests include:

1. **Salt Spray (Fog) Testing - ASTM B117-85**

Coated specimens were sheared to a 4" x 12" size and the cut edges taped to prevent corrosion. Scribe marks through the coating and into the substrate were introduced on the lower half of the panel. Test specimens were then put into a salt spray chamber. Panels were reviewed at pre-determined intervals with the last evaluation at 189 hours. Panels were rated for corrosion, not only associated with the scribe, but that which was found on the flat, unscribed areas.

2. **Water Immersion - ASTM D870-86a**

Coated specimens were partially submerged in water in a corrosion resistant container. Water permeates the coating at rates that are dependent upon the characteristics of the coating and upon the temperature of the water. Any effect such as color change, blistering, loss of adhesion, softening, or embrittlement, were observed and reported.

3. **Non-Destructive Measurement of Dry Film Thickness of Non-Magnetic Coating Applied to a Ferrous Base - ASTM D1186-81**

Film weight measurements, reported in milligrams per square inch, were taken on all variables to determine if the coating could be applied to yield the appropriate thickness.

4. **Testing Water Resistance of Coatings in 100% Relative Humidity - ASTM D2247-86**

Coated specimens were placed in an enclosed chamber containing a heated, saturated mixture of air and water vapor. The temperature of the chamber was maintained at 100°F. At 100% relative humidity, a temperature difference between the specimen and the surrounding vapor caused the formation of condensation on the specimens. Water permeated the coating at rates depending on the characteristics of the coating. Color change, blistering, loss of adhesion, softening, or embrittlement were observed and reported.

5. **Resistance of Organic Coatings to the Effect of Rapid Deformation (Impact) - ASTM D2794**

This test employed a test apparatus that consisted of a standard weight which was dropped on a coated panel to stretch and deform the organic coating and steel substrate. Failure of the coating films was made more visible by the use of a magnifier or the application of a copper sulfate ( $\text{CuSO}_4$ ) solution which reacts with the exposed steel substrate.

6. **Formability of Attached Organic Coatings with Impact-Wedge Bend Apparatus - ASTM D3281-84**

This test required that a small test sample be bent back once over itself to flatten it and then be impacted with a dead weight. After impact, the specimen was visually inspected and the entire bend area taped with a high-tack tape which was removed. The specimen was then examined for the amount of coating lifted from the substrate.

**7. Measuring Adhesion by Tape Test (Cross Hatch) - ASTM D3359-83**

A sharp cutting device was used to cut through the coating into the substrate of test specimens. A cutting guide or rule was used to produce a grid of eleven vertical and eleven horizontal cuts approximately one millimeter apart. This grid was then taped with a high-tack tape which was removed. The specimen was then rated for amount of coating removed. This test was also performed on panels that had been subjected to retort conditions of 250°F for 90 minutes.

**8. Film Hardness by Pencil Test - ASTM D3363-74**

A coated panel was placed on a firm horizontal surface. Pencils of a known hardness were held firmly against the film at a 45° angle (point away from the operator) and pushed away from the operator in a 1/4 inch stroke. The pencil that did not cut or gouge the film was recorded.

The following tests, although not ASTM methods, are standard tests used in the coating and can manufacturing industries. They are helpful when screening variables in terms of such factors as coating adhesion, uniformity, and resistance to mechanical damage.

**9. Methyl-Ethyl-Ketone (MEK) Hammer-Rub Test**

A dead weight which had been covered with several layers of cheesecloth, having been saturated with MEK, was rubbed across the surface of a coated test specimen. The number of strokes required to break through the film to the substrate was recorded.

**10. Gloss (Reflectivity)**

All exterior coatings were rated for gloss using a 60° glossmeter. Should testing reveal that several coatings were equal throughout all tests, the exterior having the lowest glossmeter rating would be the one selected.

**11. Coating Blush (Processed)**

Flat panels, having been coated with both interior and exterior coatings, were subjected to retort conditions and rated for the amount of permanent water spotting or discoloration.

**12. Can Body Manufacture**

All variables were made into traycan bodies and evaluated for coating delamination or other unacceptable features.

**13. Enamel Rating of Traycan Bodies**

All variables that made acceptable tray bodies were subjected to an enamel rating test. This test employs a salt solution used as an electrolyte and a test apparatus used as an electrolytic cell. Milliamp (Ma) readings were recorded. A high Milliamp reading is indicative of a high degree of bare metal exposed, as a result of inadequate coverage by the coating system.

**14. Susceptibility of Coating Systems to Abrasion Damage (Pickoff Test)**

Two 6" X 6" panels of the coated steel substrate were placed in direct contact. A ten-pound dead weight was then placed on the two test panels. The top panel was rotated 360° while the bottom panel remained stationary. The

interior and exterior coatings were then examined for significant abrasion damage.

#### 15. Exterior Coating Integrity Test

Traycan bodies were submerged in acidified copper sulfate for five minutes, then evaluated with regard to the existence of copper that had deposited at various locations (indicating the amount of bare metal exposure generated during the manufacture of the container).

Representatives from the Experimental Packaging Section (EPS), SPB, FTD, FED provided technical assistance and monitored the progress of this extensive battery of tests, as well as participated in the selection of variables to further evaluate under realistic conditions. Upon completion of the CSC in-house testing, a total of four coating system/steel substrate variables were selected (See Figure 3).

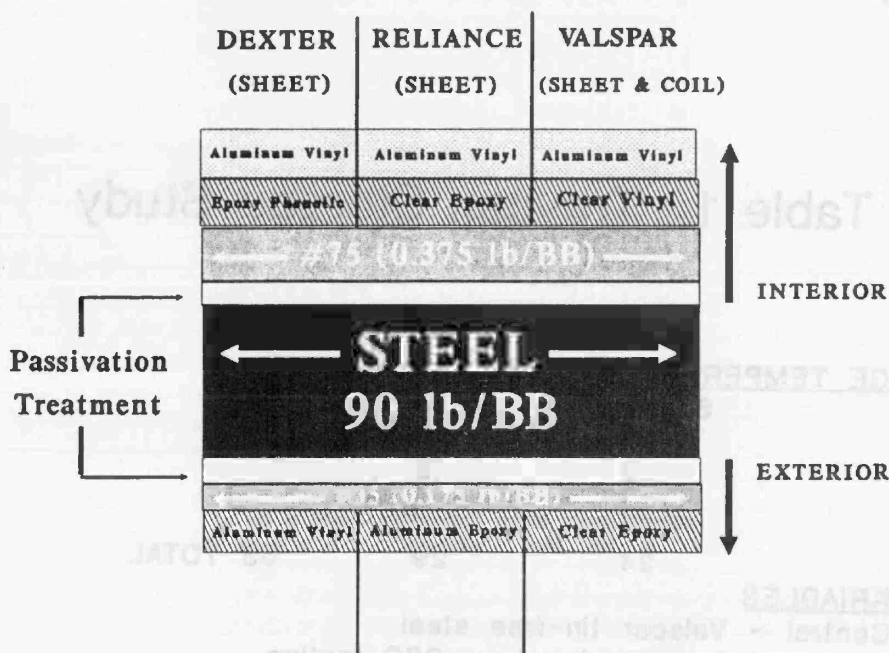


Figure 3. Final Traycan Coating Selections

The steel substrate selected was a 90 lb/BB steel plate with a #75/#35 (0.375/0.175 lb/BB) ETP coating. The four variables included representatives from each of the three coating suppliers and both application methods (i.e. sheet coating and coil coating). Only one coil coated variable was considered acceptable for further testing. The four final variables were as follows:

- Valspar                   — sheet coated, matte substrate (VMS)
- coil coated, matte substrate (VMC)
- Dexter Midland       — sheet coated, matte substrate (DMS)
- Reliance               — sheet coated, matte substrate (RMS)

The existing Valspar TFS substrate was selected as the control variable (See Figure 1).

Natick designed a storage study which included essential variables (See Table 1), such as storage temperature, can variable, coating formulation and application method and the types of food products for placement in the traycans for processing.

## Table 1. Traycan Storage Study

### STORAGE TEMPERATURES AND WITHDRAWALS

	6 MONTHS	30 MONTHS	
100°F	13	12	
80°F	7	12	
40°F	4	5	
	24	29	53 TOTAL

### CAN VARIABLES

One Control - Valspar tin-free steel  
Four best tinplate variables from CSC testing

### PRODUCT VARIABLES

Vegetables in brine (2)  
Egg product (1)  
Tomato product (2)  
Meat and gravy (1)

53 Withdrawals x 5 variables x 5 replicates x 6 products  
• 7950 trays

The Natick storage study was designed to include storage at 40, 80 and 100°F to simulate the wide temperature variation commonly found in the military supply and distribution system. Various food products were selected to represent the range of products currently being procured. Vegetable products have been found to be highly aggressive due to the high salt content of the brine. Tomato products were selected due to their high acidity. An egg product was chosen to test for product adhesion which is encountered when insufficient release agent is added to the coating resin. The meat and gravy product represents several entree items being used in the menu cycle.

The storage study consisted of two phases. Phase I was an intensive accelerated study to be completed in six months. The purpose of Phase I was to determine the best candidate, by virtue of visual and microscopic examination of both the interior and exterior of the traycan. Phase I was conducted to ensure that a final selection would be made by 15 May 1990, per request of ODCSLOG. A total of 3600 traycans were to be inspected the first six months, the majority of them from 100°F storage. Samples of each variable and the control were withdrawn from 40°F storage every 8 weeks, from 80°F every 4 weeks, and from 100°F every 2 weeks. After consultation with a statistician, it was determined that five replicates per can variable per product per withdrawal would result in a statistically valid test. Each withdrawal consisted of a total of 150 traycans (See Table 2). The withdrawal schedule can be found on Table 3.

Phase II of the storage study was designed to evaluate the traycans an additional 30 months until its completion date in December 1992. It will provide realistic data to validate the three year shelf life predictions of Phase I.

As previously stated, CSC, in conjunction with Natick, determined the best four variables and in October-November 1989, obtained the necessary materiel to initiate fabrication of the prototype traycans. Natick had determined that 1800 of each can variable was required to conduct both Phase I and II of the storage study as designed. CSC fabricated approximately 9000 bodies/lids (1800 traycans/variable) and, with full coordination with Natick and DPSC, provided them to Vanee Foods Company, Berkeley, Illinois, for filling and processing. In November 1989, these traycans were filled with 6 different products (beef stew, lasagna, chili con carne, carrots, corn and omelet w/ham). The filling and processing, attended by representatives of Natick, DPSC, and CSC, was in accordance with each component specification. The processed traycans were then packed, palletized and shipped to Natick for initiation of the storage study. The traycans were all repalletized and placed into the appropriate storage rooms by December 1989.

In December 1989, the actual inspection commenced (See Figure 4). After sample traycans were removed from storage, they were inspected for exterior defects, such as gray spots. Although there were some defects, such as abrasion and scratches (typical of the types found in commercial packs), the main concern was to find any defects that would appear to adversely affect the integrity of the traycan. Once exterior defects (if any) were recorded, the traycans were opened, emptied of product and cleaned. During cleaning, care was taken not to create defects in the interior coating. When necessary, a warm soap solution and a soft cloth were used to remove fats or oils, tomato sauce, or additional product adhering to the traycan surface. Due to some severe adherence of egg product to the two Valspar coated variables (VMC, VMS), some scrubbing of the cans was necessary. Once clean and dry, the traycans were prepared for inspection. The traycans were visually inspected for

## Table 2. Traycan Withdrawals

WITHDRAWAL - 5 CANS EACH (C)  
OF EACH PRODUCT (P)  
IN EACH OF 5 CAN VARIABLES (V)

$$5C \times 6P \times 5V = 150 \text{ CANS}$$

FOOD PRODUCT	<u>COATING VARIABLES</u>				
	<u>VMC</u>	<u>VMS</u>	<u>RMS</u>	<u>DMS</u>	<u>CONTROL</u>
CHILI	5 Cans	5 Cans	5 Cans	5 Cans	5 Cans
BEEF STEW	5 Cans	5 Cans	5 Cans	5 Cans	5 Cans
LASAGNA	5 Cans	5 Cans	5 Cans	5 Cans	5 Cans
CARROTS	5 Cans	5 Cans	5 Cans	5 Cans	5 Cans
CORN	5 Cans	5 Cans	5 Cans	5 Cans	5 Cans
OMELET	5 Cans	5 Cans	5 Cans	5 Cans	5 Cans
-----					
TOTAL	30	30	30	30	30

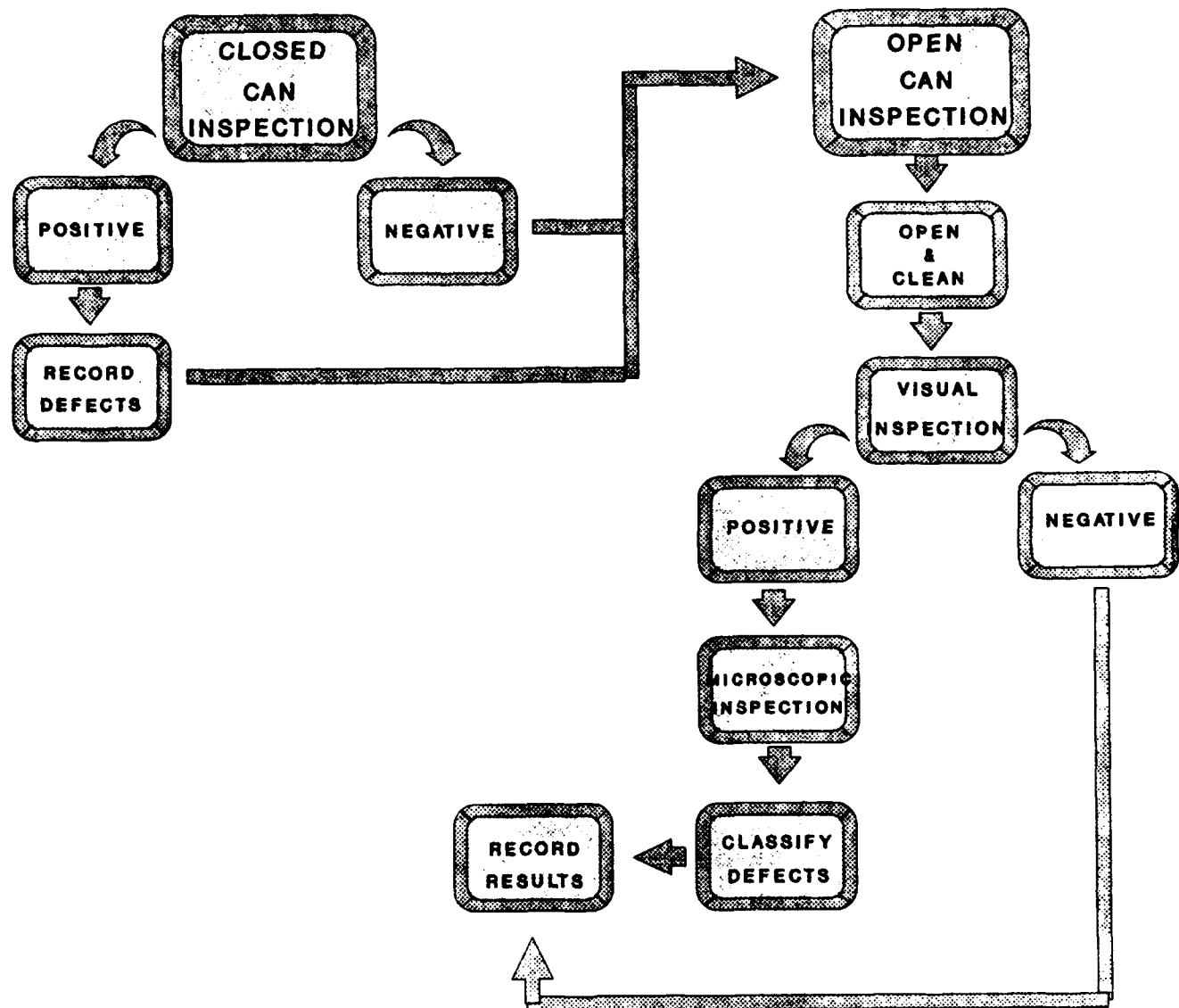
TOTAL WITHDRAWAL = 150 CANS

## Table 3. Withdrawal Schedule Phase I

<u>WEEK</u>	<u>100°F</u>	<u>80°F</u>	<u>40°F</u>
2	X		
4	X	X	
6	X		
8	X	X	X
10	X		
12	X	X	
14	X		
16	X	X	X
18	X		
20	X	X	
22	X		
24	X	X	X

$$X = 5 \text{ CANS} \times 6 \text{ PRODUCTS} \times 5 \text{ VARIABLES} = 150$$

interior defects, using a cotton swab to remove any particles adhering to the traycan. When interior defects were found, they were microscopically inspected at 70x power to further classify the defect.



## Figure 3. Traycan Inspection

For the purpose of this study, aberrations were classified and recorded in accordance with the following categories:

**Gray spot** - Appears on the can exterior in the form of small, gray colored spots. This indicates deterioration of the metal, where only the exterior coating remains intact and can easily be perforated when probed with a sharp object. Gray spots were recorded as major defects.

**Blister** - Appears as round, hemispherical projections of the interior coating from the steel substrate and is considered a major defect. Experience

with in-house and depot inspection has shown that gray spots nearly always correlate to interior blisters. Therefore, the conclusion can be made that a blister is an early indication of corrosion and, with time, will further progress to a gray spot. This is in agreement with the findings of a U.S. Army Materials Technology Laboratory study entitled Metallurgical Analysis of Leaking Tray Packs<sup>2</sup>.

**Pitted corrosion** - Corrosion of the steel substrate such that there is actual deterioration of the metal observed on the interior surface of the traycan. It is commonly found under blisters and is more easily seen with the aid of a microscope. This is also considered a major defect and one that may eventually lead to a gray spot.

**Delamination** - Lack of adhesion to the substrate or between the two enamel coatings on the interior of the traycan. Although any factor which prevents or reduces coating adhesion may subsequently create coating failures, delamination was recorded as a major defect only when it resulted in pitted corrosion or the actual peeling of the coating.

**Scratch** - An abrasion in the interior coating. This is not considered a coating defect, but one that is generally caused by mishandling prior to filling.

**Oven dust** - The adherence of oven debris to the coating surface that occurs during the curing process. This is considered an aesthetic problem and does not adversely affect the effectiveness of the coating. Oven dust was not considered a major defect.

**Coating seed** - A particle of undissolved resin left in a clump which is thicker than the surrounding interior coating. This generally will not produce corrosion and is not considered a major defect.

**Mechanical abrasion** - Damage caused by plate vs. plate movement resulting in the grinding of particles into the coating. This defect occurs mainly in the coil coated roll stock during handling and storage and is classified based on the severity. This is sometimes erroneously referred to as pickoff.

For the purpose of this study, defects that were difficult to classify visually were examined using a 70x power microscope. This also enabled the inspector to further investigate the characteristics of the aberrations (e.g. existence of product or pitted corrosion underneath a blister).

## RESULTS AND DISCUSSION

The results of the extensive visual and microscopic examination of the four traycan variables and the control are contained in Tables 4 - 28. Several observations should be noted as evidenced in Tables 4 - 28:

1. DMS consistently exhibited the smallest number of major defects, with approximately 3% of total traycans inspected. DMS also had the lowest number of total aberrations, with approximately 18%. At 24 weeks, DMS exhibited a 90% reduction in major defects, as compared to Control (see Table 24).

2. The TFS Control consistently exhibited the largest number of major defects, particularly blisters, with approximately 37% of the traycans observed having some form of a major defect. In fact, the majority of total aberrations were major defects. This is clearly demonstrated in Table 28.

3. As shown in Tables 25, 26, and 27, the 40°F samples had a lower incidence of major defects than the 80°F and 100°F samples.

4. Of the tinplate variables, RMS had the highest incidence of major defects, with approximately 25%. As shown in Tables 4 - 15, this is more obvious in the 100°F samples.

The following list captures additional observations and developments that are not evident from Tables 4 - 28:

1. Gray spots were not found in any of the tinplate variables during the first six months of testing.

2. A gray spot was found in the Control variable in the Beef Stew product after 20 weeks storage at 80 °F.

3. From the initiation of the storage study, a severe product adherence problem existed involving omelet w/ham and the Valspar variables (VMC and VMS). This is apparently due to insufficient product release agent in the coating and is considered a critical problem. The product adhesion may be remedied with the addition of more release agent to the coating resin. However, it may present other problems, e.g., reduced coating adhesion, increased delamination and reduced corrosion resistance which would warrant further test packs.

4. Blisters appeared at the early stages of the study in the Control and RMS variables. The number of blisters per can did not increase but their size and severity did.

5. There was a 7-8% incidence of delamination in the VMC variable. This commonly appeared as a direct result of an exterior defect, e.g., a dent. This is considered a critical problem due to the exposure of the traycan to rough handling within the military storage and distribution system. This delamination is due to poor adhesion of the coating system to the tinplate substrate.

6. There was no progression of oven dust and coating seeds to major or critical defects. These are considered to be aesthetic aberrations and do not adversely affect the integrity of the traycan. Oven dust is common in the can industry and can be kept to a minimum by maintaining clean curing ovens. Coating seeds are also common industry problems and can be avoided by assuring that coating resins are blended appropriately and applied as uniformly as possible.

7. There was a 11-13% incidence of mechanical abrasion damage to the coating in the VMC variable. Although there was no progression to major defects, this is considered a critical problem in the can industry, especially in coil coated tinplate. This aberration occurred primarily in the traycan

lids which, due to a lack of cushioning between lids during packing, are subjected to metal to metal contact during storage and distribution. Mechanical damage may be avoided by developing a coating system which is more resistant to such damage.

8. Overall, the traycan body is more susceptible to defects than the traycan lid due to the deeper draw in forming the body.

9. Omelet was found to be the most aggressive of the six products tested. The major defect rate of the various products are as follows:

Omelet w/ham .....	49%
Beef Stew .....	29%
Corn .....	27%
Chili .....	13%
Carrots .....	2%
Lasagna .....	1%

These defect rates are evenly distributed among the five traycan variables.

### CONCLUSIONS

1. The optimum can variables, in terms of exhibiting the fewest number of major defects are, in descending order, as follows:

1. DMS (Dexter Midland, Matte ETP, Sheet coated)
2. VMS (Valspar, Matte ETP, Sheet coated)
3. VMC (Valspar, Matte ETP, Coil coated)
4. RMS (Reliance, Matte ETP, Sheet coated)
5. Control (Valspar, TFS, Coil coated)

The product adhesion problem with the VMS and VMC can variables preclude them from further consideration as contenders to replace the current Valspar TFS traycan. In addition, the high incidence of delamination in the VMC variable further eliminates it as a serious contender. However, both VMS and VMC will continue to be evaluated during Phase II of this study. Again, the product adhesion problem may be remedied with the addition of more release agent to the coating resin. However, this may present other problems, e.g., reduced coating adhesion, increased delamination, and reduced corrosion resistance, and would warrant further test packs.

2. Blisters are an early indication of potential corrosion problems, which are accelerated by storage conditions and product aggressiveness.

3. Tinplate systems did provide improved resistance to corrosion over the current Valspar TFS traycan during 6 month storage at 40, 80 and 100°F, as evidenced by data showing the superior performance of the tinplated can variables. This was investigated further via metallurgical studies and the findings are discussed in a Natick report entitled Evaluation of Candidate Coatings for the Traycan Improvement Program on Tinplate Versus the Present Tin-Free Coating System<sup>5</sup>

4. Higher storage temperatures adversely affect the performance of all can variables. This is typical of canned products.

5. The high acid products (containing tomato sauce) did not appear to be as highly aggressive to any of the can variables as the low acid products.

6. The brine in the vegetable products does not appear to be a consistent contributing factor to traycan corrosion. This is demonstrated by the low defect rate of the carrots in brine as compared to the higher defect rate of the corn product.

#### RECOMMENDATIONS

1. Recommend that the traycan composition be #75/#25 (0.375/0.125 lb/BB) differentially coated tinplate with an aluminum vinyl/epoxy phenolic double coating system, and that a sheet feed system be used in lieu of the current coil feed system. The recommendation to convert to this new traycan with tin weights of #75/#35 was made to and accepted by ODCSLOG on 16 May 1991. However, #75/#35 is a non-standard coating weight and requires substantial lead times, resulting in increased costs. Initial mill surveys indicated that this tin ratio balance was required in order to coil coat a steel substrate with an interior tin coating of #75. The use of a #35 exterior coating for the purpose of the Traycan Storage Study was due to the requirement for coil coating and not from a need to control exterior corrosion. Due to the recommendation to convert to a sheet feed system, the additional 0.05 lb/BB on the exterior is not needed. This recommendation was discussed with CSC and provided to DPSC in December 1990.

2. Recommend that test packs be conducted on all new Tray Pack products being considered for future procurements. Test packs must be evaluated for a minimum of 6 months at a storage temperature of 100°F. Test packs are necessary to determine that certain products do not adversely affect the integrity of the traycan and exhibit the capability of meeting the minimum three years at 80°F shelf life of the Department of the Army.

3. Recommend that inspection protocol for the traycan interior be deleted from all Tray Pack specifications. This protocol has resulted in inaccurate classification of interior defects and, consequently, contributed to production delays and, in some cases, termination of production.

4. Recommend that Natick increase participation in the packing process, particularly when traycan problems arise. To accomplish this objective, improved communication has been established within Natick, and among Natick, USDA and DPSC.

5. As outlined in the Tray Pack Task Force, recommend that care continue to be exercised throughout the manufacturing, transporting and handling of traycans to avoid mechanical defects that may adversely affect the integrity of the coating system and, therefore, the performance of the traycan over time.

This document reports research undertaken at the US Army Natick Research, Development and Engineering Center and has been assigned No. NATICK/TR-9/1030 in the series of reports approved for publication.

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8. The Canned Food Reference Manual, A publication of American Can Company Research Division, American Can Co., 1947.

**APPENDIX**  
**INSPECTION RESULTS**

Table 4. 2 Weeks @ 100°F.

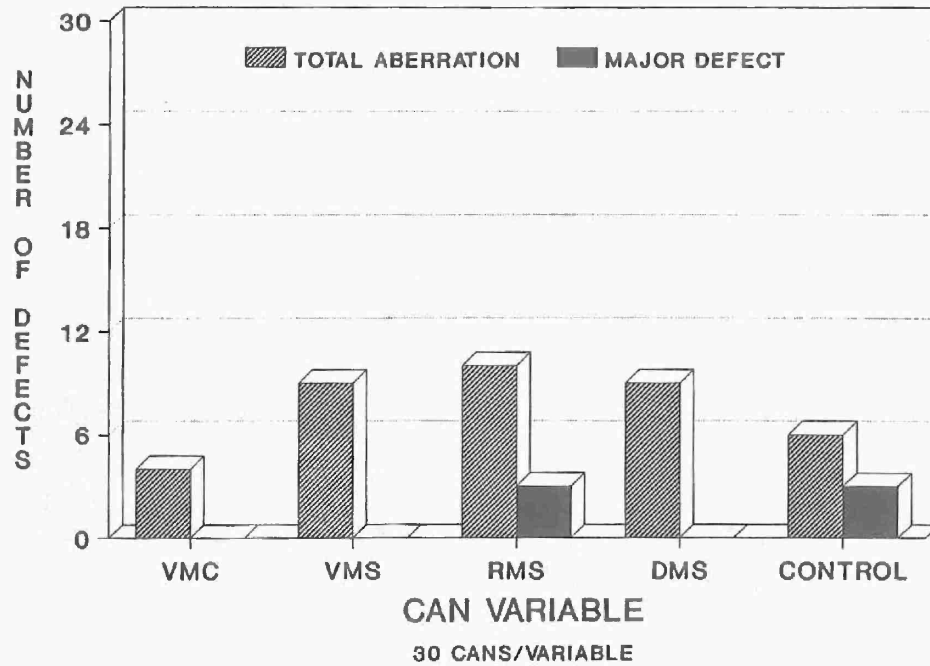


Table 5. 4 Weeks @ 100°F.  
CUMULATIVE

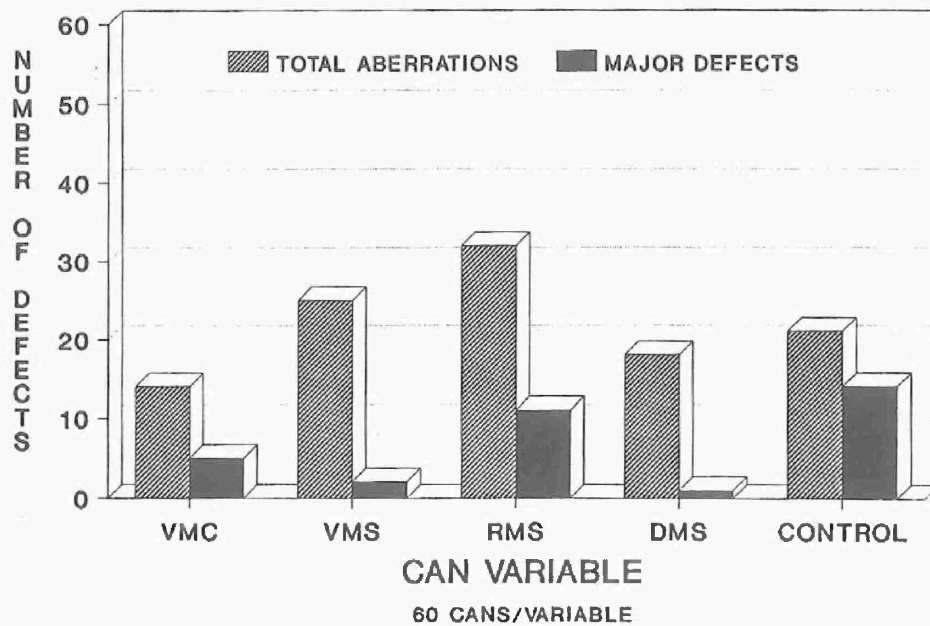


Table 6. 6 Weeks @ 100°F.  
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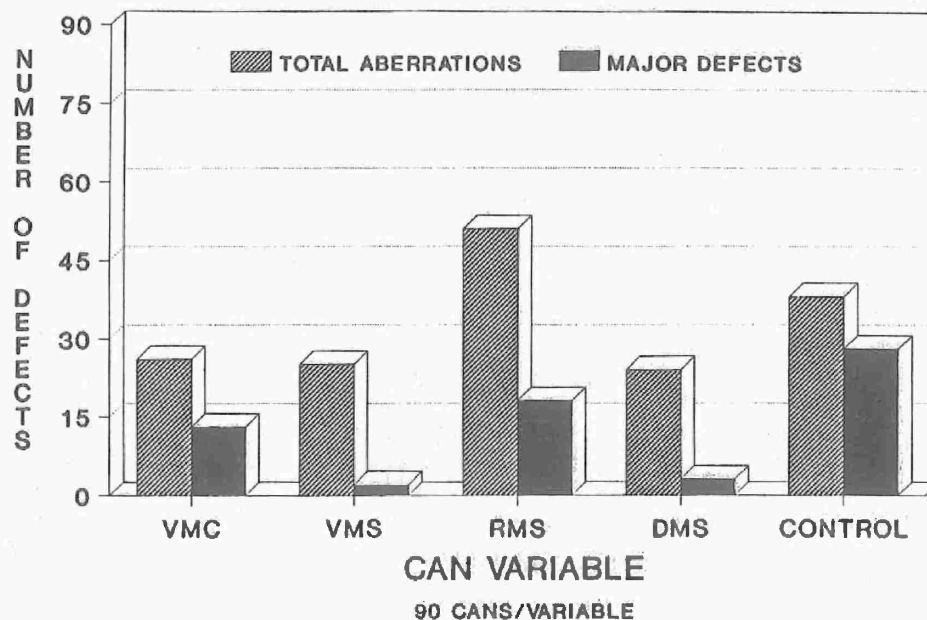


Table 7. 8 Weeks @ 100°F.  
CUMULATIVE

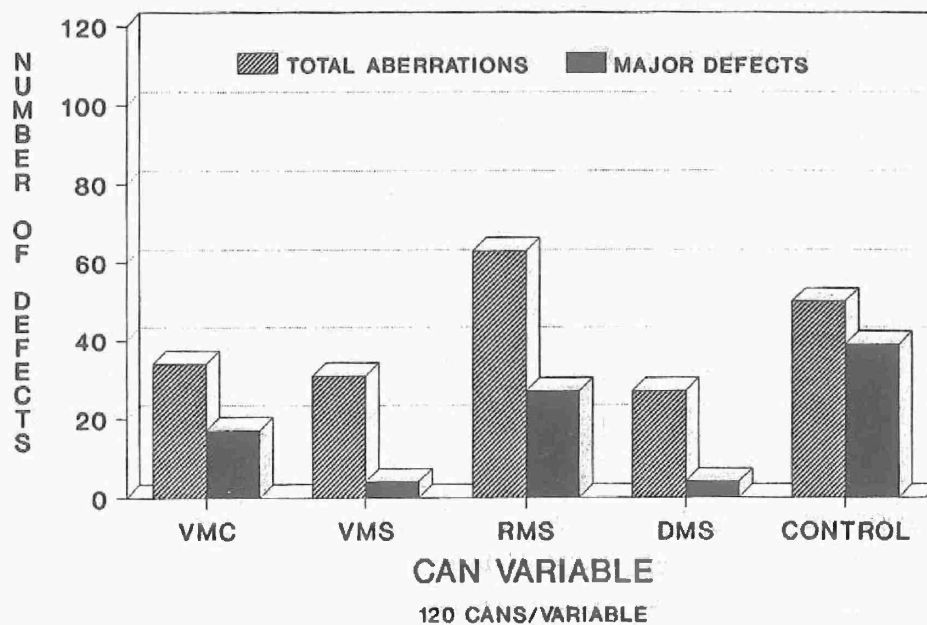


Table 8. 10 Weeks @ 100°F.  
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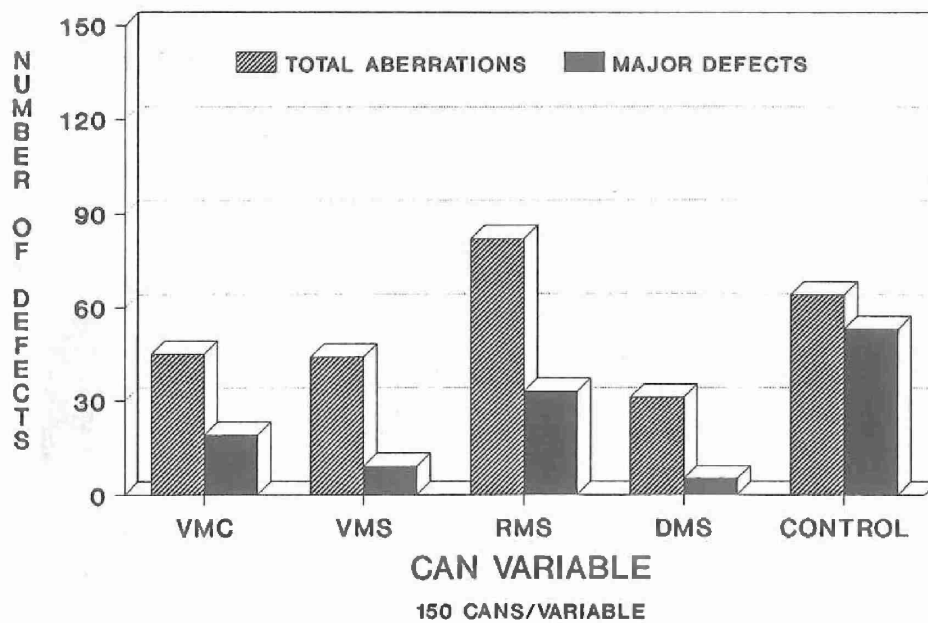


Table 9. 12 Weeks @ 100°F.  
CUMULATIVE

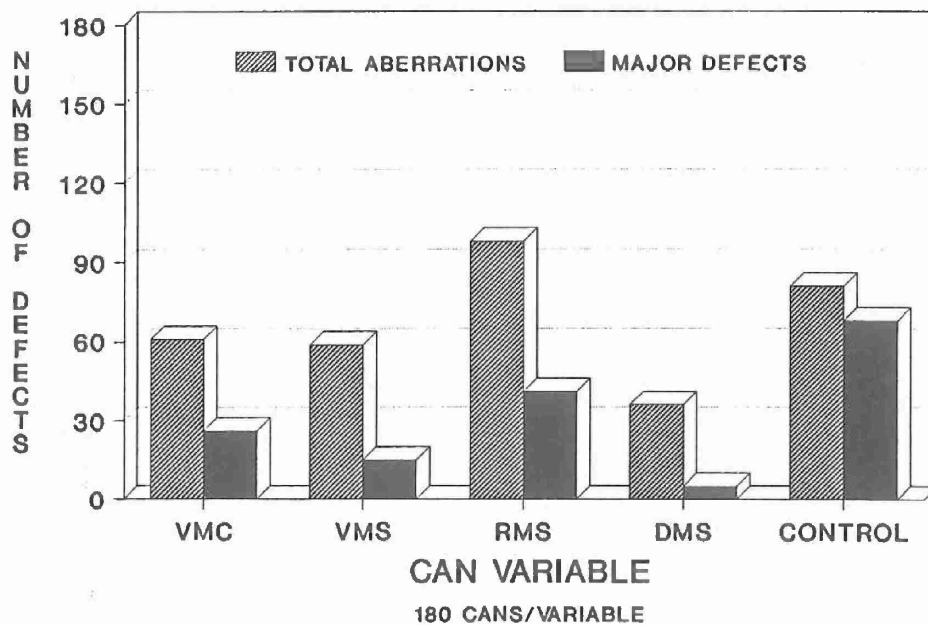


Table 10. 14 Weeks @ 100°F.  
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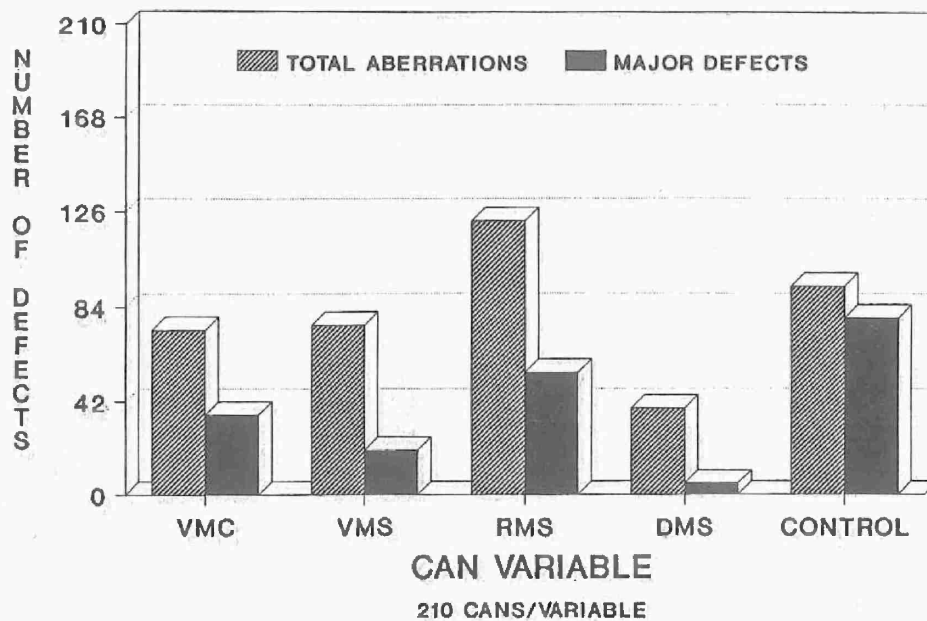


Table 11. 16 Weeks @ 100°F.  
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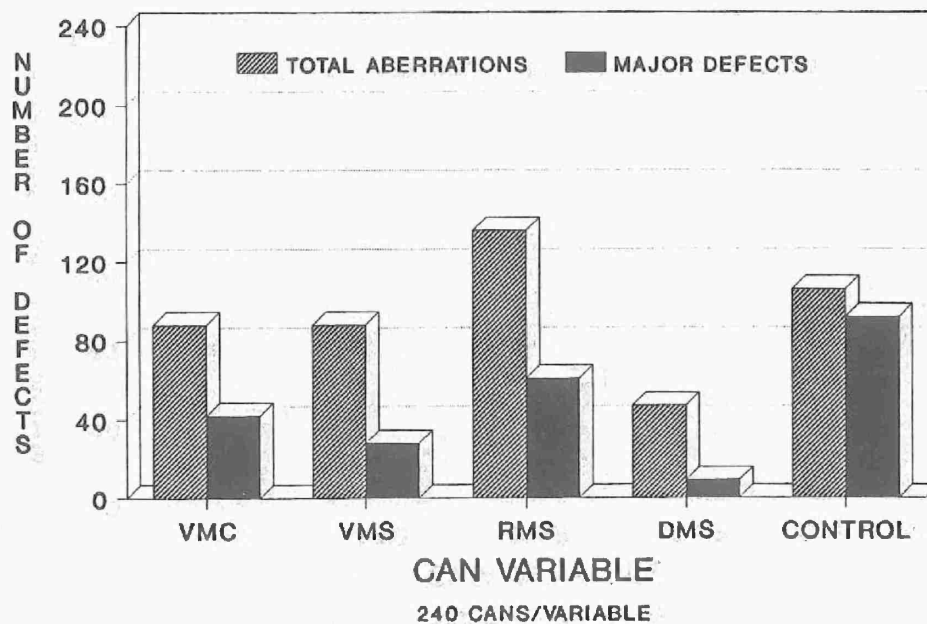


Table 12. 18 Weeks @ 100°F.  
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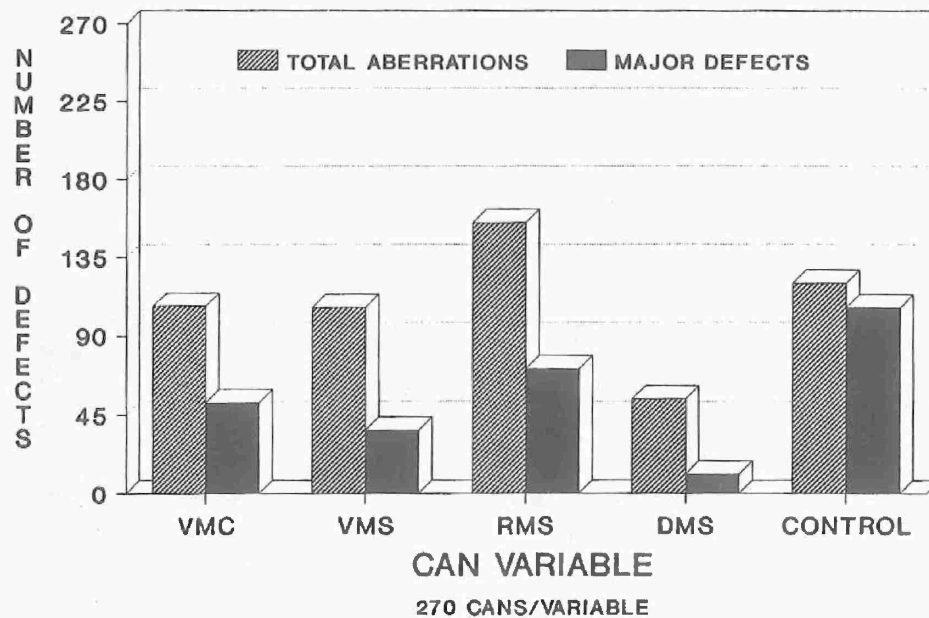


Table 13. 20 Weeks @ 100°F.  
CUMULATIVE

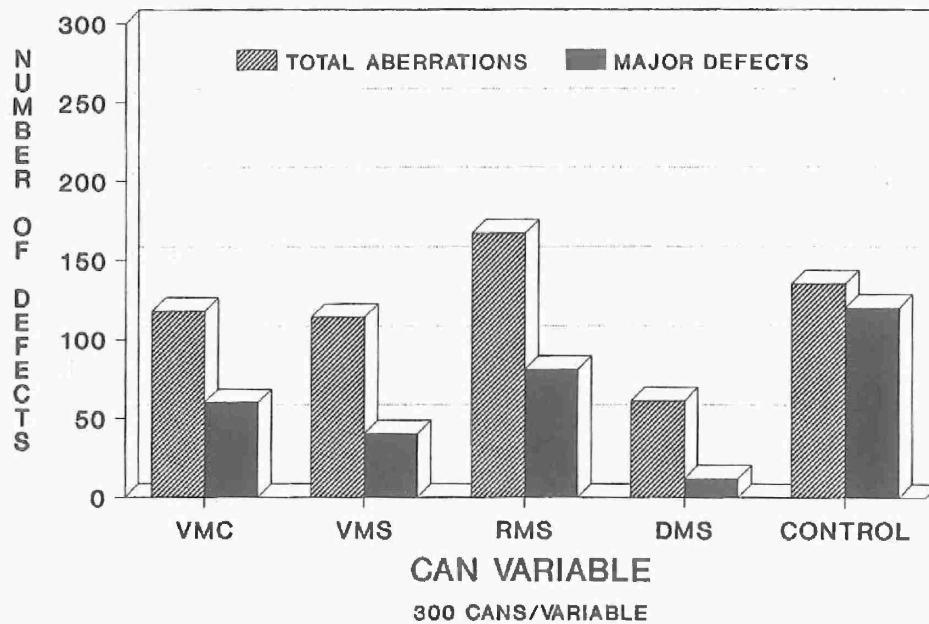


Table 14. 22 Weeks @ 100°F.  
CUMULATIVE

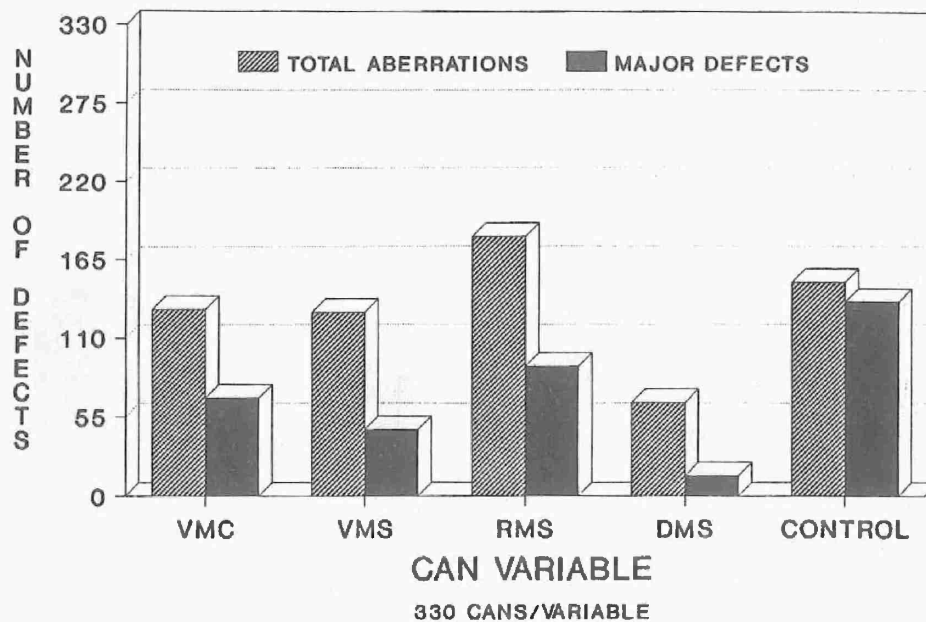


Table 15. 24 Weeks @ 100°F.  
CUMULATIVE

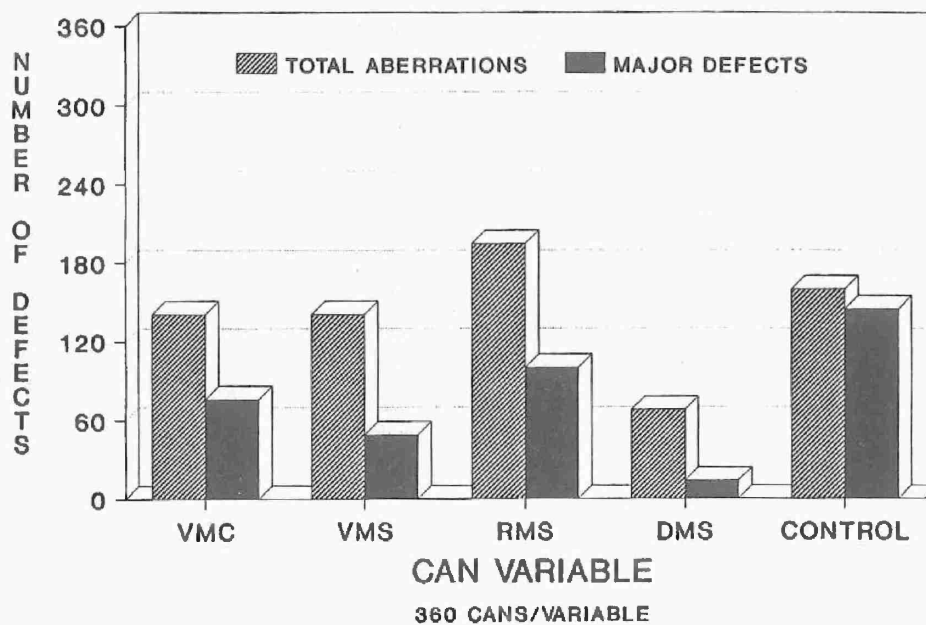


Table 16. 4 Weeks @ 80°F.

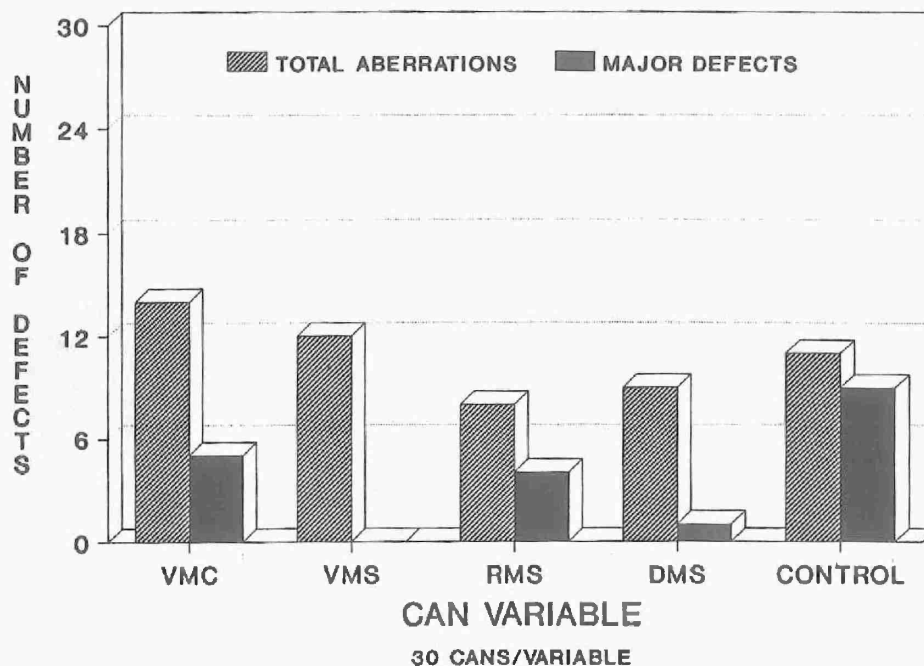


Table 17. 8 Weeks @ 80°F.  
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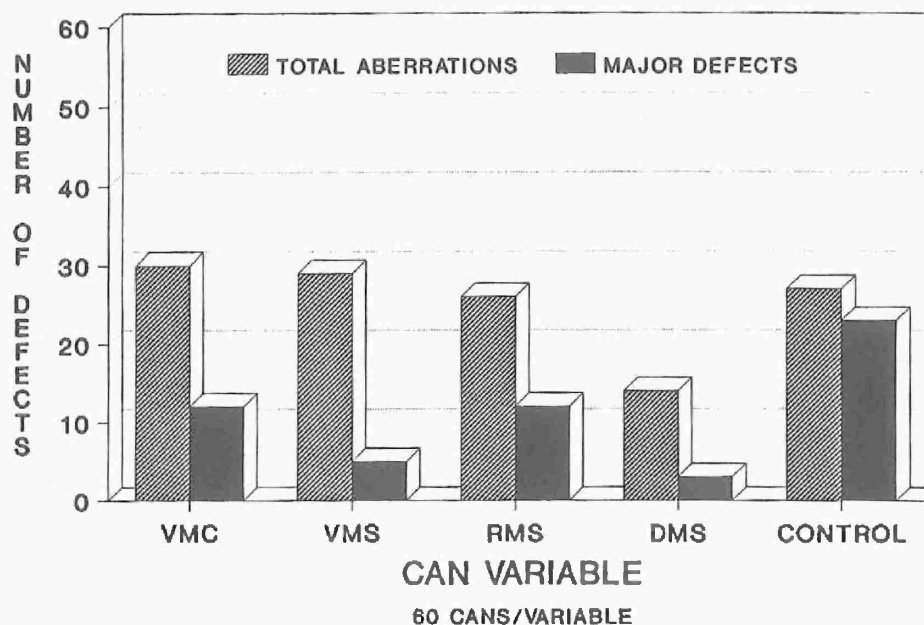


Table 18. 12 Weeks @ 80°F.  
CUMULATIVE

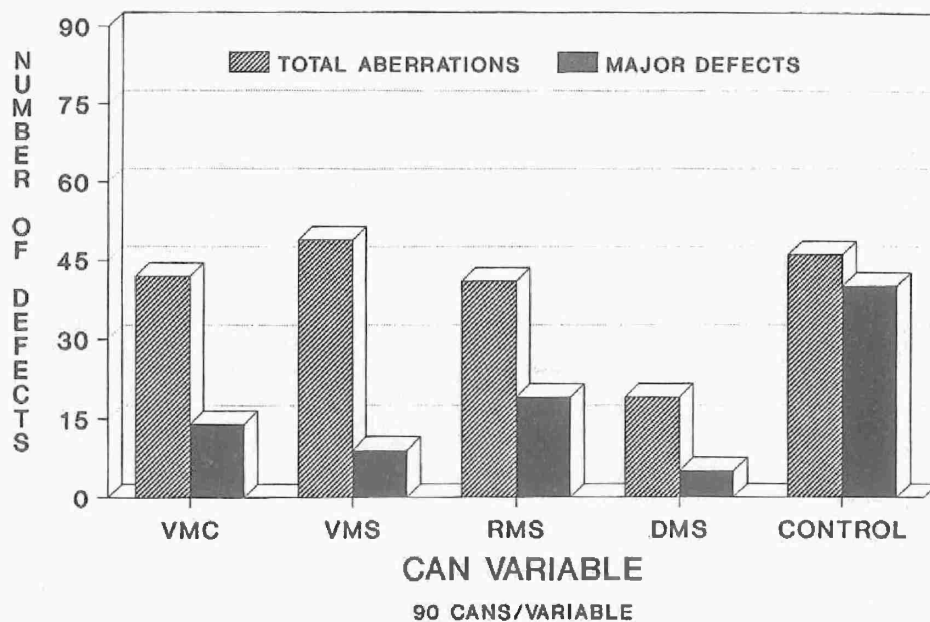


Table 19. 16 Weeks @ 80°F.  
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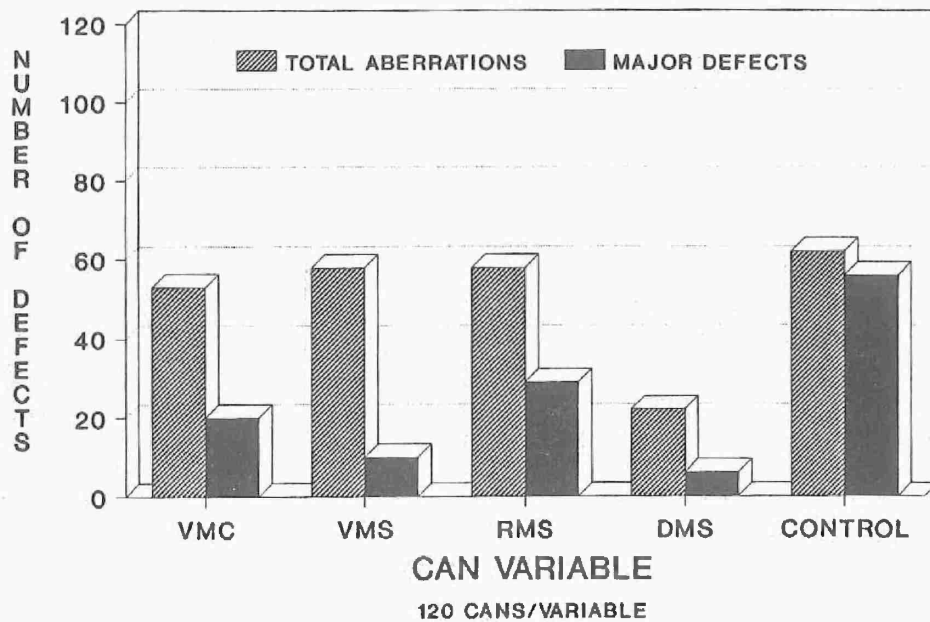


Table 20. 20 Weeks @ 80°F.  
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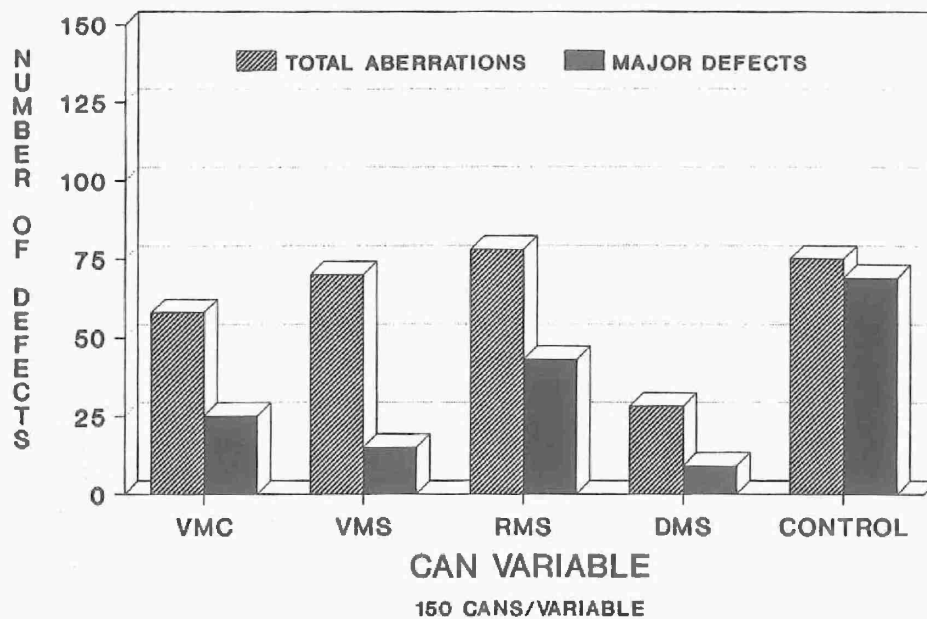


Table 21. 24 Weeks @ 80°F.  
CUMULATIVE

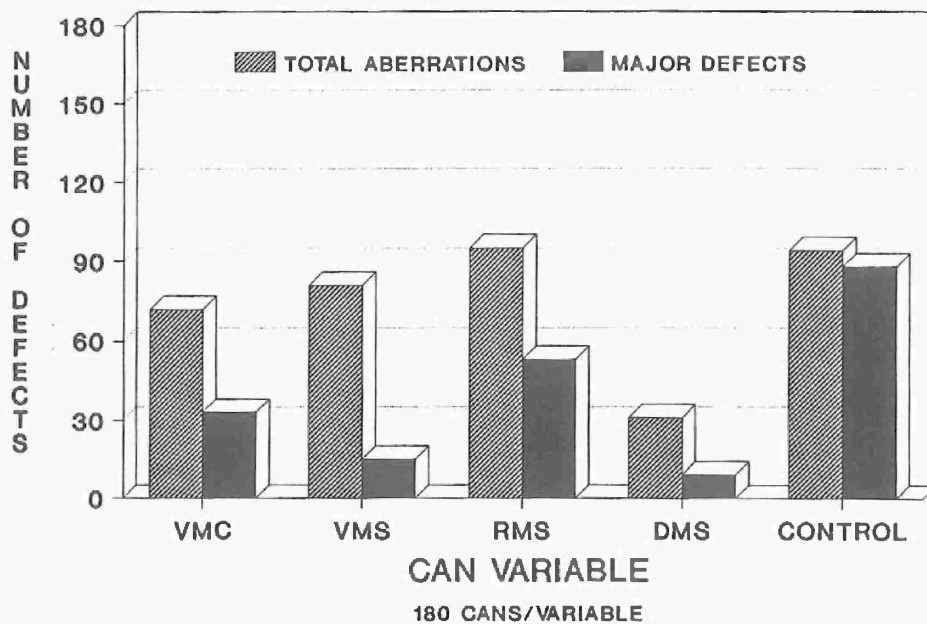


Table 22. 8 Weeks @ 40°F.

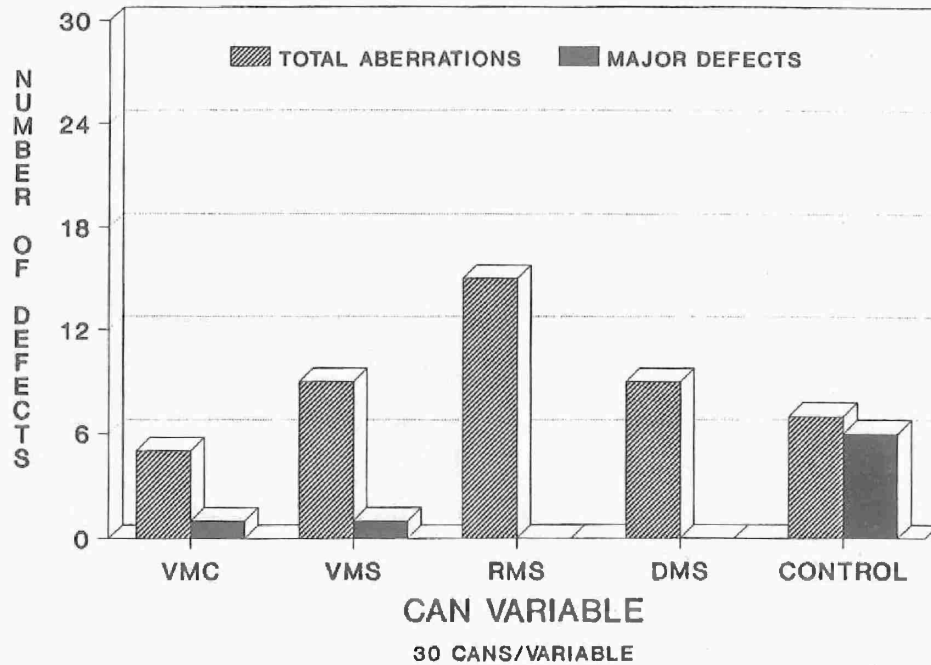


Table 23. 16 Weeks @ 40°F.  
CUMULATIVE

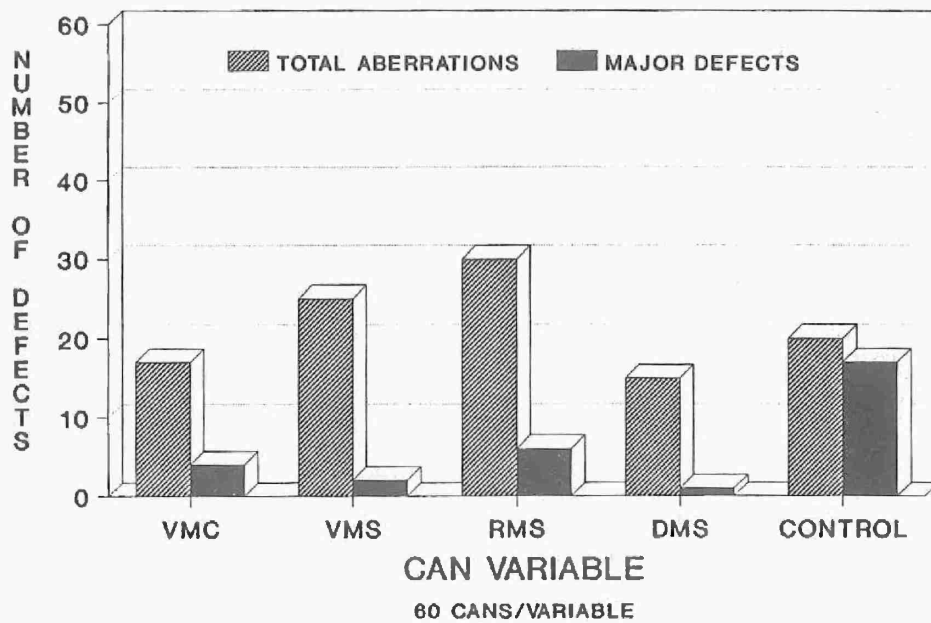


Table 24. 24 Weeks @ 40°F.  
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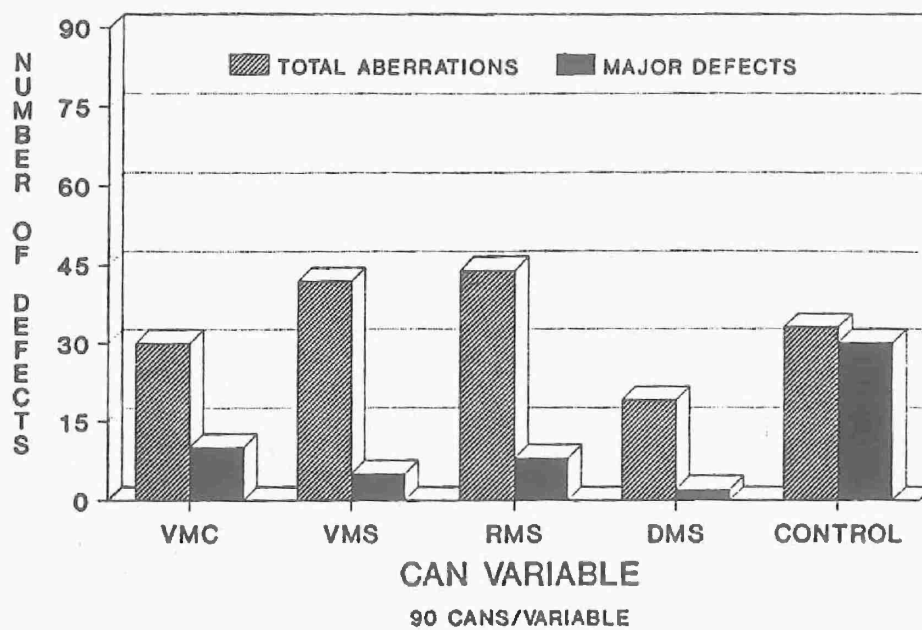


Table 25. 8 Weeks @ 40,80 & 100°F.  
CUMULATIVE

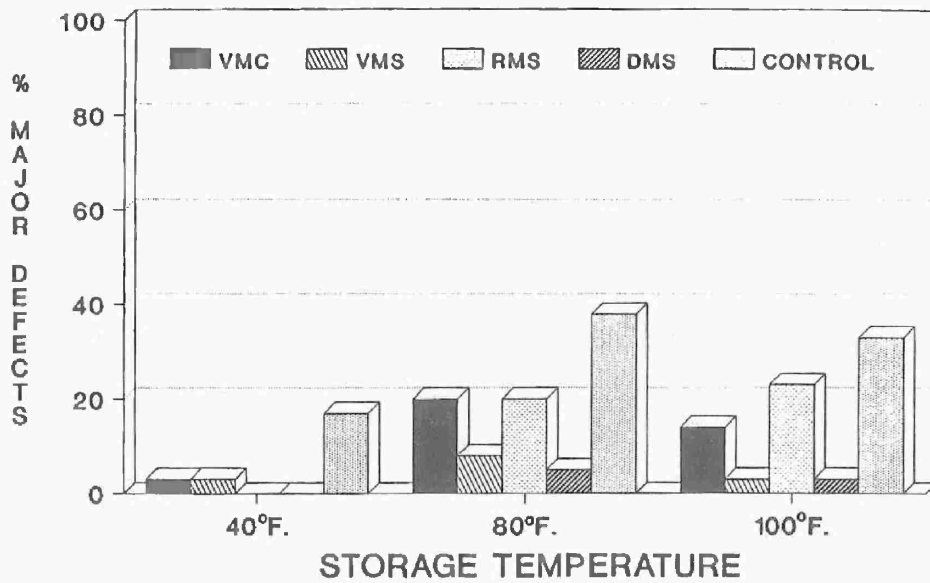


Table 26. 16 Weeks @ 40,80 & 100°F.  
CUMULATIVE

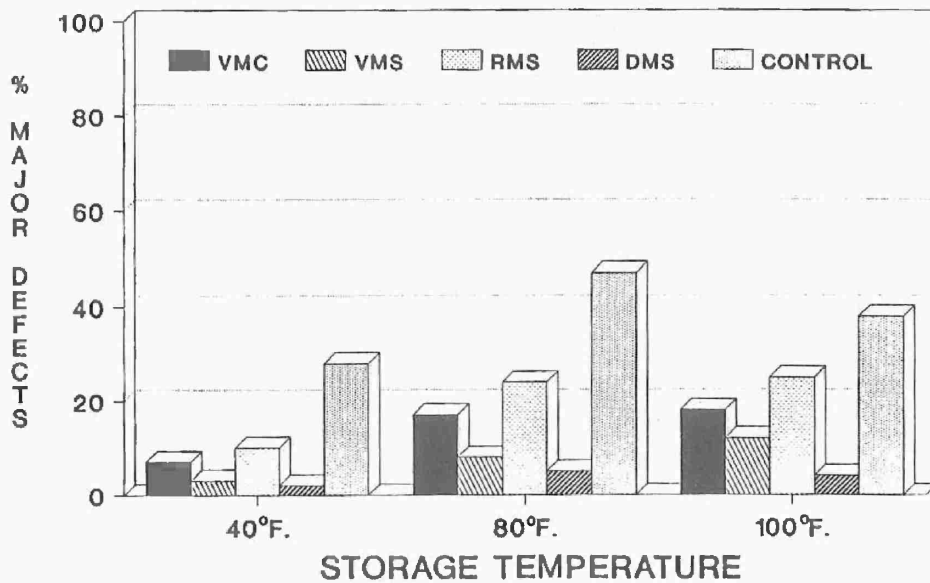


Table 27. 24 Weeks @ 40, 80 & 100°F.  
CUMULATIVE

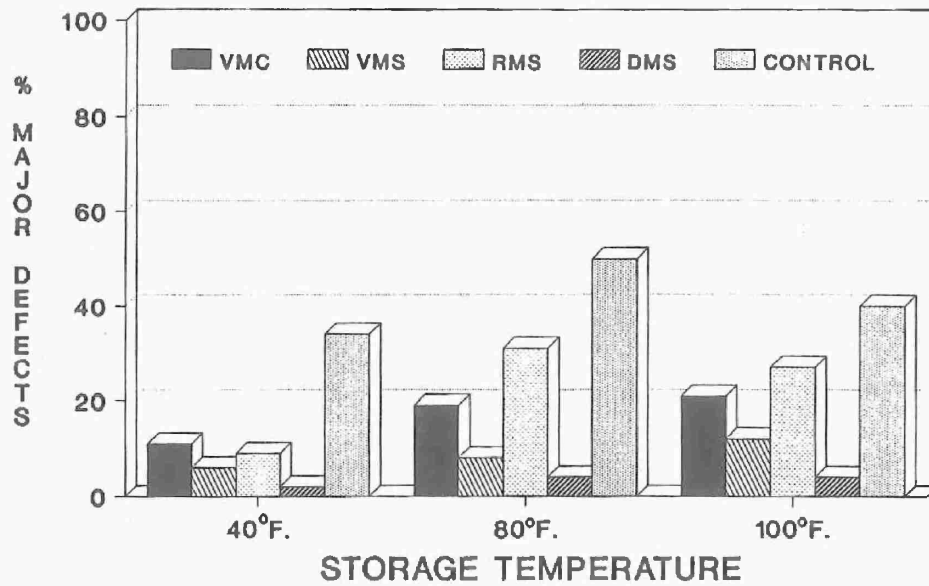
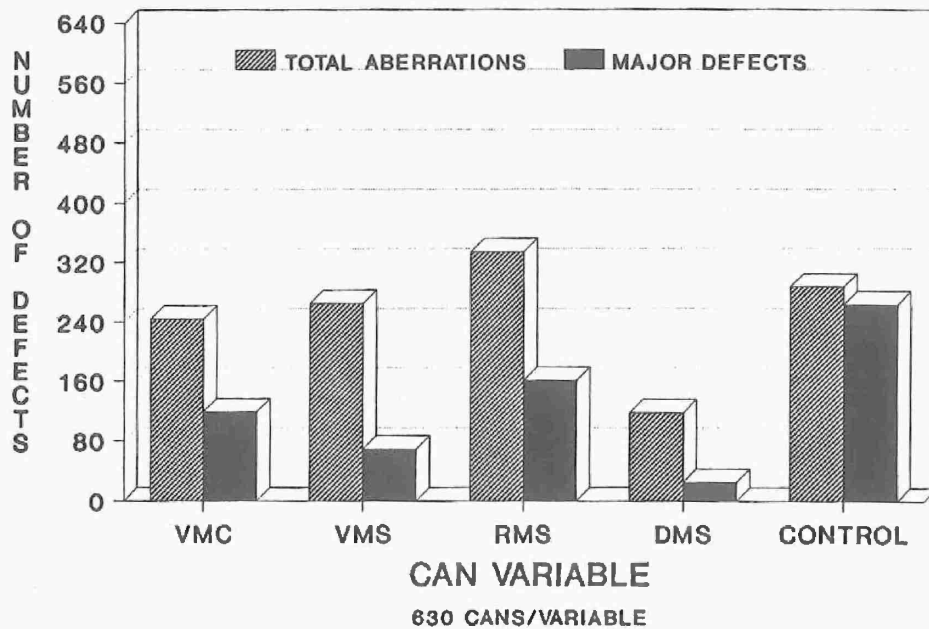


Table 28. 24 Weeks @ 40,80 & 100°F.  
CUMULATIVE



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